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ABSTRACT

This is a general information document describing the Hertfordshire Computer Managed Mathematics Project funded over a four-year period by the National Development Programme in Computer Assisted Learning. Its aims were to develop a two-year course for all-ability 11-to 13-year-old pupils and to implement a computer system to serve the course. This course would then be fully institutionalized within Hertfordshire and made available to other Local Education Authorities. The project has reached the point that development is giving way to production both for [illegible]l and external use. Two courses are described in detail: (1) an individualized linear mathematics course divided into 25 topic-oriented modules to cover two years of instruction, and (2) a course of arithmetic tests covering the basic skills and concepts presented in the first course. Future concerns are added flexibility of routing and decentralization of control. (VT)

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COMPUTER MANAGED LEARNING

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THE HERTFORDSHIRE MATHEMATICS PROJECT

Developments such as the teaching of mixed ability groups, the integration of the teaching of mathematics with other subject areas, and the adoption of various methods of self-paced learning, all raise problems. We may accept the validity of the educational objectives, but there are many difficulties to overcome if mathematics is to be taught within such a framework without any impairment of the pupils' performance by previously accepted criteria.

T.J. FLETCHER. H.M.I.
(Trends in Education - Oct. 1974)

The Hertfordshire Computer Managed Mathematics Project (to give it its full name) offers a SOLUTION to the PROBLEMS faced by TEACHERS in teaching secondary school ALL ABILITY classes in mathematics.

The Project aims to provide a service to the teacher by managing and reporting pupil progress through a course of mathematics.

THE PROJECT PROVIDES THE SERVICE - THE TEACHER PROVIDES TUITION.

A STEP TOWARDS IMPROVED CLASSROOM MANAGEMENT
IN A DIFFICULT AREA.

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INTRODUCTION

The Hertfordshire Computer Managed Mathematics Project (HCMMP) originated from an investigation at Hatfield School, Hertfordshire, into the use of a computer managed system within a first year all-ability mathematics course. In 1972 money was injected into the scheme by the National Development Programme for Computer Assisted Learning (NDPCAL) and by Hertfordshire County Council. Development funding was planned for four years, after which time the package was to be capable of being fully institutionalised within Hertfordshire and any other interested Local Education Authority.

This publication aims to provide details concerning the Project at a level beyond that of simply the casual observer.

OBJECTIVES

The objectives of the Hertfordshire Computer Managed Mathematics Project are to produce a two year computer managed mathematics course to be followed by all-ability secondary school first and second year classes, and to establish that course on an institutionalised and viable basis.

HISTORY

In the two years prior to becoming comprehensive in 1971, the mathematics staff at Hatfield School had been experimenting with individualised teaching methods in their classes. Their aim was to produce a strategy for teaching mathematics to all-ability classes of 11 to 13 year old children. The experiments suggested that the main problems in individualised teaching lay in the management of the pupils as they progressed at different rates through the course of work.

Investigations that followed centered around the use of the computer as a management tool and led to the design of a structured course written in such a way that it could be marked and managed by a computer. The course was worksheet based and pupils submitted their answers to the computer by way of optical mark sensed cards. The computer would assess the work, allot remedial tasks on the basis of assessment, print the results to the pupil and provide suitable feedback to the teacher in the way of accumulative registers.

With the advent of NDPCAL funding an independent project was set up in September 1973 at the Advisory Unit for Computer Based Education under the directorship of Dr. W. Tagg. A complement of three educationalists, four administrative and ancillary personnel and a transfer officer was appointed during the development phase.

The aim of the Project was to:

(i) develop a two year mathematics course for 11 to 13 year old pupils in all-ability classes,

(ii) implement a computer system that would service the course,

(iii) evaluate and document all its findings,

(iv) tailor the package so that it could be assimilated within the L.E.A. at reasonable cost.

The project started work with four pilot schools and a one year course, aiming at a gradual expansion during the development period to about twelve schools and a two year course. The project also kept in mind the problems of portability and investigated, where possible, the use of the project materials in other institutions.

NATIONAL DEVELOPMENT PROGRAMME IN COMPUTER ASSISTED LEARNING (NDPCAL)

The National Development Programme in Computer Assisted Learning began its five-year life on 1 January 1973, with a budget of up to £2 million. The Programme's gestation period was lengthy. Six years earlier, in December 1967, the National Council for Educational Technology, itself less than a year old, decided to set up a Working Party:

1) to investigate the potential of the computer as a component of educational and training systems in the United Kingdom taking into account, as necessary, experience and trends in other countries.

2) to outline a systematic programme of applied research and development which it would be desirable to encourage in this country, aimed at exploiting the computer to the best advantage in education and training.

(NCET, 1969a, p.2)

In 1969, following the Working Party's report and a subsequent large feasibility study (NCET, 1969b), NCET set out the case for a 5-year, £2 million programme in 'computer based learning' (NCET, 1969c).

The Government, following much discussion amongst the interested departments and an intervening general election, announced its approval of a 'national development programme in computer assisted learning' in a DES press release dated 23 May 1972.

The Programme has two main aims, the first of which was formulated in January 1973 and runs throughout the five years, the second was added in 1974 and will be given specific attention in the second half of the Progamme's lifespan. The two aims are:

1) to develop and secure the assimilation of computer assisted and computer managed learning on a regular institutional basis at reasonable cost;

2) to make recommendations to appropriate agencies in the public and private sector (for example, DES, UGC, Computer Board, L.E.As. Ministry of Defence, computer manufacturers) concerning possible future levels and types of investment in computer assisted and computer managed learning in education and training.

The products of the first aim should be, if the Programme is to be adjudged a success, examples of computer assisted and computer managed learning that have been successfully institutionalised.
These working examples should be in a reasonable range of academic disciplines and across the various sectors of education and training.

The Products of the second aim will be a series of short reports making recommendations about computer assisted and computer managed learning up to, probably, 1985. These reports will contain a series of generalisations, based on the experience of the projects, special studies, commissioned during the course of the Programme, and other work both in the UK and abroad.

EXTRACTED FROM THE REPORT "TWO YEARS ON" BY THE DIRECTOR OF THE NDPCAL, RICHARD HOOPER.

GENERAL PROJECT PHILOSOPHY

The Project's philosophy has been formulated around the following major principles:-

1. The course is designed for all-ability classes, and assumes pupils have a reading age of at least 9 years.

2. The course should prove a satisfactory foundation to subsequent mathematics courses in the later school years.

3. The course should be a balance of modern and traditional ideas.

4. The work should be structured to satisfy the logistics of computer assessment in so far as this does not conflict with educational demands.

5. The computer system should be flexible enough to allow -

   (a) the teacher to override its directions.

   (b) the teacher to fall back on his own methods of assessment and direction should the technology break down.

6. That although the work is individualised the 'group' identity of the class should not be destroyed.

7. Arithmetic is a necessary skill to be learnt and constantly practised.

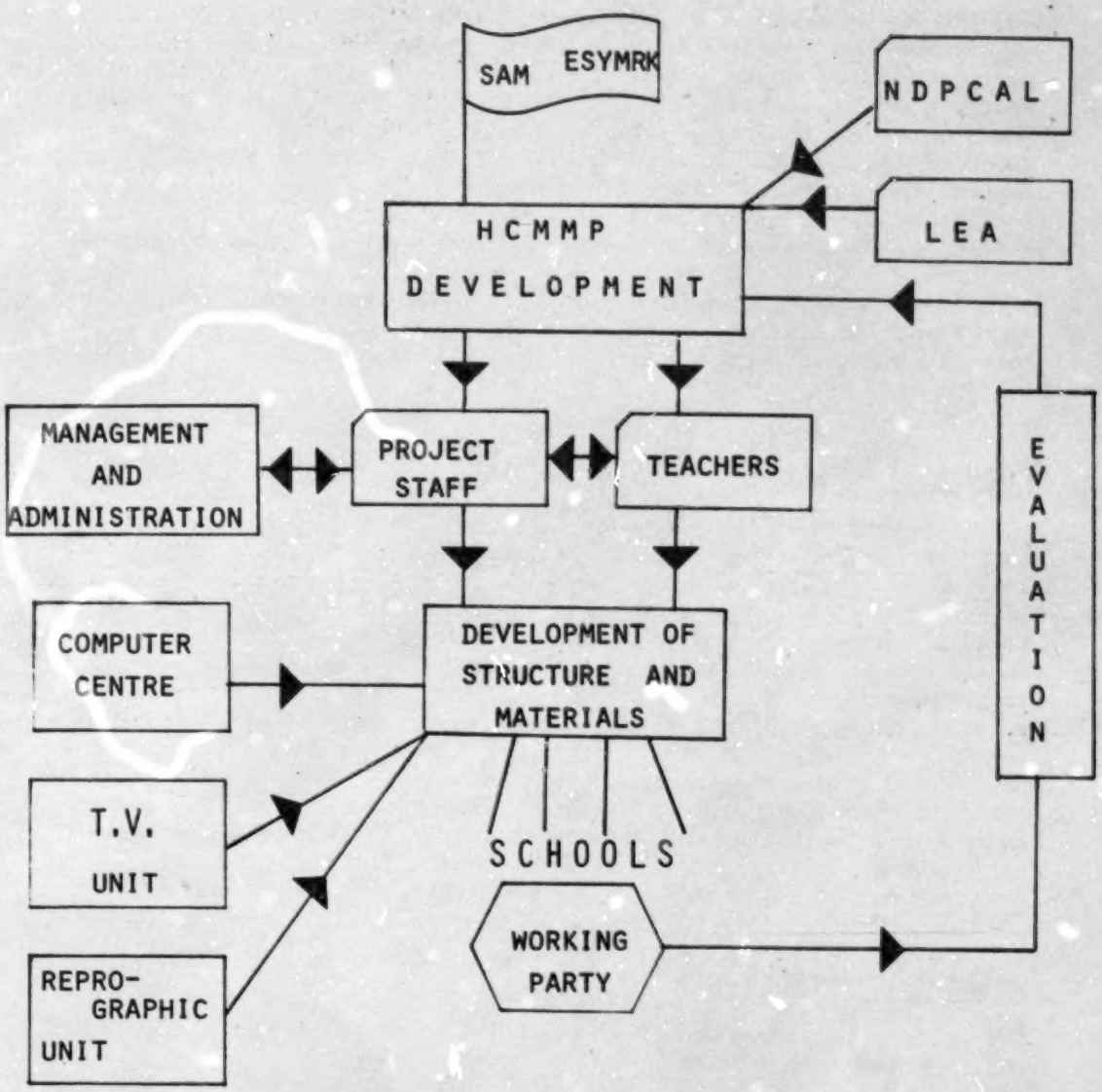
8. Development is continuous.

9. That in development the user of the Project material (the teacher in the classroom) should be involved in as many of the decisions and development issues as possible.

10. The Project should function within existing school and local education authority facilities.

11. The cost of the Project, whilst largely an 'add-on' cost rather than a marginal cost, should be reasonable.

PROJECT STRUCTURE



EDUCATIONAL MATERIAL

The educational material is divided into two distinct packages -

ESYMRK : a 'cautiously modern' worksheet based course

SAM : an arithmetic tester and practice course

ESYMRK

ESYMRK is an individualised linear, mathematics course constituting approximately 90% of the HCMMP course. The syllabus covers the first two years of secondary school and is divided into 25 identifiable sections called modules (12 in the 1st year and 13 in the 2nd year). The modules are topic oriented and hence in educational terms form separate identities. Each module is uniquely numbered and it is implied that Module 1 comes before Module 2 etc. There are however facilities for 'floating' modules (optional to the mainstream) such as Module 50, that can be fitted into the course as the teacher desires.

As the course has been developed for all-ability classes, and as all the children in the class are attempting the module, the work is sufficiently demanding for the brighter children, whilst also containing sufficiently easy material for the less able.

MODULE PROFILE

At the beginning of a module all the pupils in the class are brought together to view a video-tape television programme (lasting approximately 15 minutes). The video programme aims to introduce the new section of work to the pupils in a light-hearted and entertaining way. In addition, it helps to retain the group identity by bringing the children together as a class at intervals during the course. In general, the teacher is recommended to follow the video with a 'chalk-and-talk' session, raising important points to be covered in the module and re-inforcing ideas developed in the video programme. The pupils will then all start on the most elementary worksheet in the module and progress towards the most difficult. The class will complete the module when the teacher is satisfied that even the slowest pupil has achieved the central mathematical objectives, usually after 2 or 3 weeks. The class will then be brought together again for the start of the next module.

WORKSHEET STRUCTURE

The worksheets in general, are structured into four levels A, B, C, D that are summarised below:

A	Simple language, introductory concepts
B C	main body of teaching material
D	more challenging work for faster, more able pupils.

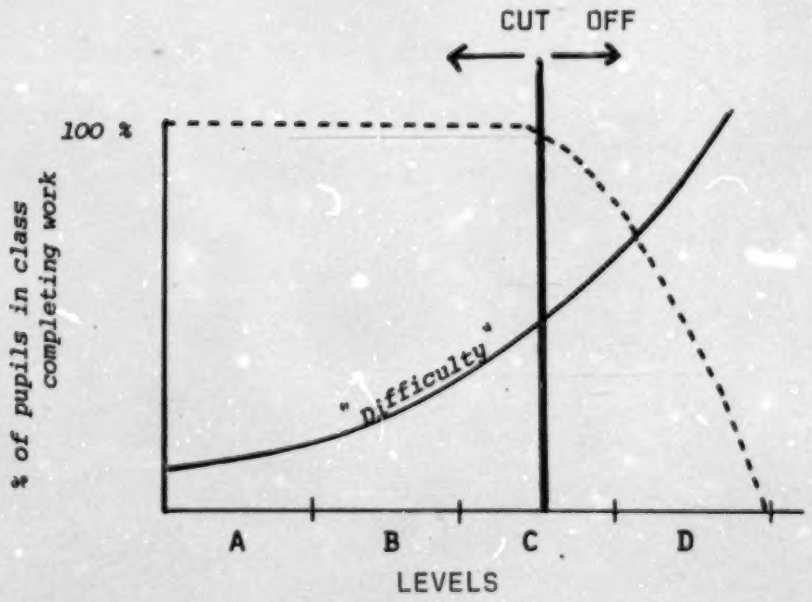
Within each level there are three worksheets -

M	T	X
Machine marked	Teacher marked	eXtra practice (machine marked)

The three worksheets in a level will generally develop the same concepts at the same level of difficulty. However, the format of the questions will differ. On the M sheet, only 'closed' questions with short answers are asked. On the T sheet more open-ended question are asked. On the X sheet the questions are similar in format to the M sheet, but pupils attempt questions as dictated by the results of their attempts at the M sheet. Thus the X sheets provide remedial work or extra practice, for pupils who have not grasped the concept(s) developed earlier in the level. Pupils continue working through the levels at their own pace until all pupils have reached the 'cut off' as defined by the educational objectives of the module.

It is expected that more able pupils will quickly complete the work at the A and B levels, skipping over most of the X sheet work, and hence progress onto more demanding work on levels C and D. Beyond the 'cut off' no new topics, central to the course are introduced.

The Project puts foward the graph below to characterise the difficulty (solid line) and the number of pupils expected to attempt each worksheet (broken line) in a typical module.



WORKSHEET C2M

H.C.F.

THIS IS A TYPICAL WORKSHEET FROM THE MODULE ON 'NUMBER' THE ASSOCIATED PRINTOUT IS SHOWN OPPOSITE

▶ The factors of 12 are {1, 2, 3, 4, 6, 12}

▶ The factors of 15 are {1, 3, 5, 15}

1 and 3 are factors of both 12 and 15.

We call these COMMON factors of 12 and 15.

▶ Write down all the factors of 18 and 12.

1. What are the common factors?

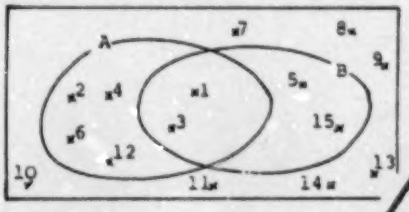
Q1	1, 2, 3

▶ What are the common factors in each of the following?

2. 12 and 20 ?	Q2 1, 4, 2
3. 9 and 24 ?	Q3 1, 3
4. 10 and 25 ?	Q4 5
5. 6 and 30 ?	Q5 6, 2, 1
6. 15 and 18 ?	Q6 1, 3, 5

▶ We can show the common factors on a Venn diagr

Look at this one for the factors of 12 and



A =

B

▶ The common factors are in the

Draw Venn diagrams for Q2 -

The factors of 12 are {1, 2, 3, 4, 6, 12}

The factors of 15 are {1, 3, 5, 15}

The common factors of 12 and 15 are {1, 3}

▶ Sometimes we need to know which is the highest common factor. We call it the H.C.F.

The Highest Common Factor of 12 and 15 is 3.

7. What are the common factors of 12 and 18?

8. What is the Highest Common Factor?

9. What is the H.C.F. of 10 and 15?

What are the H.C.F.s of the following?

10. 9 and 15 ?
11. 16 and 24 ?
12. 6 and 12 ?
13. 10 and 20 ?

Q10	3
Q11	4
Q12	3
Q13	10

Q7	1, 2, 3, 6
Q8	6
Q9	10

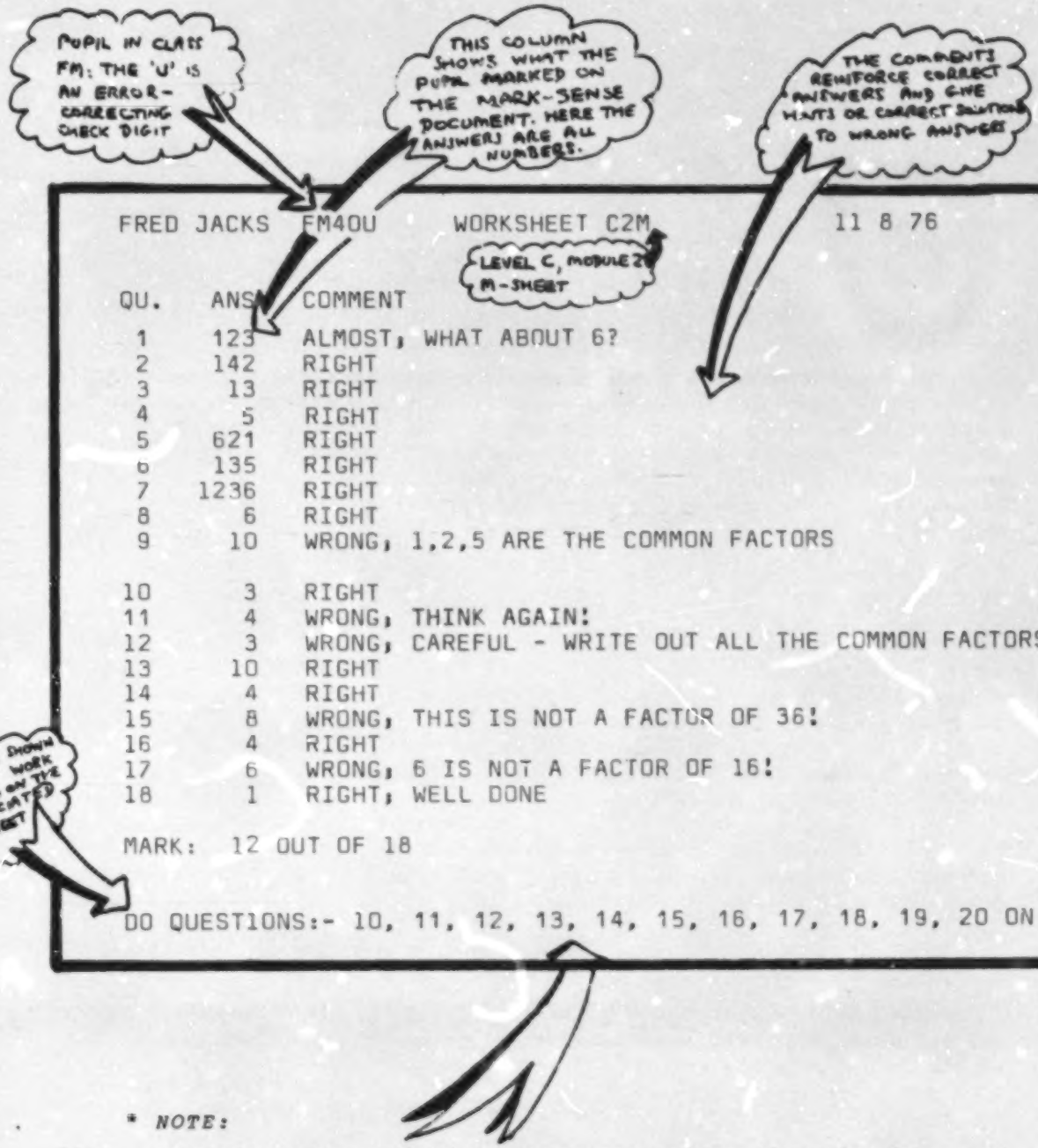
14. 4 and 36 ?
15. 16 and 36 ?
16. 8 and 12 ?
17. 12 and 16 ?

Q14	4
Q15	5
Q16	4
Q17	6

The Professor has another problem! He has to find the H.C.F of 7 and 11. Can you help him?

18. Write the H.C.F. of 7 and 11 in the answer box.

Q18	1


PUPIL IN CLASS FM: THE 'U' IS AN ERROR-CORRECTING CHECK DIGIT
THIS COLUMN SHOWS WHAT THE PUPIL MARKED ON THE MARK-SENSE DOCUMENT. HERE THE ANSWERS ARE ALL NUMBERS.
THE COMMENTS REINFORCE CORRECT ANSWERS AND GIVE HINTS OR CORRECT SOLUTIONS TO WRONG ANSWERS
FRED JACKS FM40U WORKSHEET C2M 11 8 76
LEVEL C, MODULE 2 M-SHEET
QU. ANS COMMENT
1 123 ALMOST, WHAT ABOUT 6?
2 142 RIGHT
3 13 RIGHT
4 5 RIGHT
5 621 RIGHT
6 135 RIGHT
7 1236 RIGHT
8 6 RIGHT
9 10 WRONG, 1,2,5 ARE THE COMMON FACTORS
10 3 RIGHT
11 4 WRONG, THINK AGAIN!
12 3 WRONG, CAREFUL - WRITE OUT ALL THE COMMON FACTORS
13 10 RIGHT
14 4 RIGHT
15 8 WRONG, THIS IS NOT A FACTOR OF 36!
16 4 RIGHT
17 6 WRONG, 6 IS NOT A FACTOR OF 16!
18 1 RIGHT; WELL DONE
MARK: 12 OUT OF 18
DO QUESTIONS:- 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 ON C2X
PUPIL SHOWN WHAT WORK TO DO ON THE ASSOCIATED X-SHEET

* *NOTE:*

This is the scheduling from M to X. Fred Jacks does not seem to have grasped HCF (five of these questions are wrong) so he is told to do extra practice on this topic on the X sheet. The teacher will have been informed of Fred's difficulty on the registers.

COMPUTER INVOLVEMENT IN ESYMRK

The computer is involved in four ways -

(i) to assess the pupils' work

(ii) to schedule pupils from an M worksheet to an X worksheet.

(iii) to provide adequate feedback to the teachers on pupils' achievement

(iv) to provide objective data to authors to aid evaluative studies.

ASSESSMENT

All M and X worksheets can be marked by the computer. To achieve this a pupil codes his answers to a worksheet onto a specially-prepared document which is subsequently processed by the computer. The pupils' answers are compared with a list of anticipated responses and marked appropriately. Helpful comments may be added by the author of the worksheet. The marking and comments are printed and sent to the pupil who can then attach them to his worksheet.

SCHEDULING

Routing occurs between M and X sheets of each level. This scheduling is specified by the author of each module. He may elect to divide each M sheet into a number of blocks, each corresponding to a block on the relevant X sheet. Marks gained on the M sheet block are used to determine how many of the questions in the X sheet block are to be set. Blocks can vary in size from a single question to the whole sheet and need not contain any questions at all on the X sheet.

This form of scheduling may seem rather simplistic but 'it is realistic and workable', especially bearing in mind the need for flexibility should teacher intervention be required.

PROGRESS REPORTS

The teacher is provided with the facilities to obtain a number of reports detailing pupil attainment and progress. Two of these reports are in the form of CURRENT and HISTORY registers. The CURRENT register reports on a daily basis, the details of the module(s) currently being attempted by the class, highlighting a number of easily definable problems. The HISTORY Register is a less detailed report on any module previously attempted by the class. A third report gives an accumulative summary of pupil attainment over all modules attempted and for those teachers that want it, a ranking within the class.

(opposite: register information and associated pupil marking)

HCHMP ESYHRK 24 04 76

CURRENT REGISTER FOR CLASS [redacted]

MODULE 03

TOTAL NUMBER OF QUESTIONS

	AM	AT	AX	BM	BT	BX	CM	CT	CX	DM
	17			20			20			00
HP40U	17		17/18	19		20/20	15		13/15	
HP41Z	16		13/16	14		18/20	15			
HP42Y	17		12/17	20		20/20	15			
HP44W	17		14/17	20		20/20	16			
HP45V	16		15/17	14		19/20	15		12/1	
HP50V	16		16/18	19		20/20	12			
HP51U	17		17/17	17		17/20	16			
HP52Z	16		15/18	20		20/20				
HP53Y	16		18/19	19		20/20	15			
HP54X	16		17/18	20		20/20	15			
HP55J	16		17/18	19		16/20	16			
HP60W	16		18/18	20		20/20	1			
HP61V	17		17/18	19		20/20				
HP62U	15			10						
HP63Z	16		17/17	15		20/20				
HP64Y	17		15/16	20		20/20				
HP65X	17		18/18	20		18/20	14			
HP70X	17		17/17	17		20/20	14			
HP71W	16		16/17	20		18/20	16			
HP72V	17		18/18	20		20/20	15			
HP73U	16		18/18	20		17/20	11			
HP74Z	16		18/18	20		20/20	14			
HP75Y	16		16/17	20		20/20	13		11/15	
HP80Y	17		16/17	20		20/20	15			
HP81X	16		17/17	15		20/20	13		10/15	
HP82W	17		17/18	17		20/20	16		13/15	
HP83V	17		16/18	20		14/19	16			
HP84U	17		18/18	20		2?/20	[illegible]			
HP85Z	16		10/17	20		20/20	16			

PUPILS ARE NOT NECESSARILY SCHEDULED ONTO THE SAME QUESTIONS

HP73U

QN.	ANS	COMMENT
1	15	RIGHT
2	16	RIGHT
3	36	RIGHT
4	38	RIGHT
5	23	RIGHT
6	A	RIGHT
7	8	RIGHT
8	3	RIGHT
9	10	RIGHT
10	11	RIGHT
11	30	RIGHT
12	31	RIGHT
13	03	RIGHT
14	24	RIGHT
15	22	RIGHT
16	63	RIGHT
17	44	WRONG) D IS AT (3,3)
18	42	WRONG) A MOVES TO (4,4)
19	30	WRONG) B MOVES TO (5,4)
20	92	WRONG) C MOVES TO (5,2)
	22	WRONG) D MOVES TO (4,2)
		RIGHT) A MOVES TO (3,1)
		WRONG) C MOVES TO (1,0)
		WRONG) D MOVES TO (1,1)
		QUESTION NOT ANSWERED

TOTAL MARK 11 OUT OF 20

******* TODAY'S RUN *******
* PROJ NO ERRORS IN SCH*

C3X1
C3M
M

IN THIS COLUMN LIST OF WORK SUBMITTED LAST EVENING

WORKSHEET C03M 29 07 76

PUPIL'S SHEET

CURRENT RUN CODES: * INCORRECT WORKSHEET NO.
@ QUESTIONS OMITTED
! SCHEDULING IGNORED
% BAD MARKING
# 3 QUESTIONS WRONG IN SEQUENCE
& M SHEET AT THIS LEVEL NOT DONE
? NUMEROUS OF ABOVE

TEACHER INPUT:

REQ U REQ REQ REQ REQ REQ

TEACHER MAY OVERRIDE THE SCHEDULING

THESE CODES AMPLIFY THE INFORMATION IN THE 'TODAY'S RUN' COLUMN

TEACHER HAS REQUESTED A SPECIAL ACTION — IN THIS CASE, THAT THE NEXT MODULE BE INITIATED FOR HIM: FROM NOW ON, HE WILL RECEIVE REGISTERS FOR MODULE 4 AS WELL AS FOR MODULE 3.

SAM

S A M, standing for "SET and MARK", is a course of arithmetic tests covering what are judged to be the basic arithmetic skills and concepts at which a pupil should be competent by the end of the first two years of secondary school mathematics. While some pupils demonstrate adequate facility in manipulative skills up to and beyond decimal arithmetic, others may exhibit various conceptual deficiencies in work as basic as place-value. There is a demonstrable need for a sure diagnostic aid which would enable the teacher to pinpoint and remedy these deficiencies. The SAM system endeavours to do this.

In general terms authors design arithmetic test 'pictures' into which the computer inserts controlled random numbers and hence compiles and prints a "pupil-unique" test paper. Pupils working through the test papers submit to the computer their answers to the questions. These answers are matched against computer compiled answers and marked accordingly. The computer then generates a new test paper graded according to the results of the marked paper.

Each question is unique, within the bounds of randomisation, and hence no one pupil will get the same question as any other.

The S A M course can be described as follows:

i) The course is divided into identifiable sections called STANDARDS.

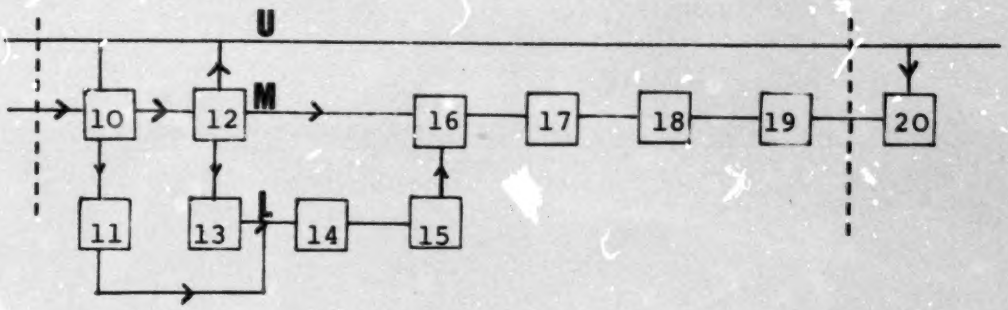
ii) The standards are designed to cover one arithmetic concept, tested over a number of questions.
In general the standards are grouped together into larger BLOCKS of like concepts.

iii) The management of pupils' progress through the standards allows the more able pupil to progress quickly to a new concept block by 'passing' the KEY TEST set on entry to a block.

THE COURSE

The course is divided into up to 999 standards grouped into concept identifiable BLOCKS. Each standard question paper is generated from an author defined standard 'picture' that is held in a computer file Each standard BLOCK tests the ability of a pupil at an educationally identifiable arithmetic concept by way of a KEY TEST. The figure shows the possible progress beyond the KEY TEST.

ROUTING CHART



The KEY TESTS in the figure are standards 1Ø and 12 (12 is a second chance). From there pupils can go one of three ways, termed

U - upper route; to next BLOCK (KEY TEST 2O)

M - middle route; extra practice on concept

L - lower route; needing further examination and practice.

Pupils naturally progress along the flow lines unless set in LIMBO, i.e. the sequence: answer question paper - computer assessment - computer set and print new paper, is stopped before the set and print stage and the pupil is directed to the teacher. The last standard in a block will be a post test for all pupils who follow the middle or lower route. (i.e. standard 19).

THE STANDARD

A standard is the global term that describes the position of a question paper in the course of the work. The question paper generated at a particular standard will contain a number of arithmetic questions that will determine the ability of a pupil to cope with a particular concept. The KEY TEST standards will show overall ability at the concept. The lower and middle standards will attempt to test the finer points and hence give a better indication of where a pupil is experiencing difficulties.

EXAMPLE

Block 10 - 19 could be testing addition. A pupil who fails the KEY TESTS may be successfully adding digits that produce no carry, but be unable to cope with the carry. It may be difficult to ascertain that fact from KEY TEST results and hence require more finely graded tests.

WORKING STRUCTURE

In general pupils work through SAM at their own rate, dictated only by their own enthusiasm or ability or the availability of time in class for this activity.

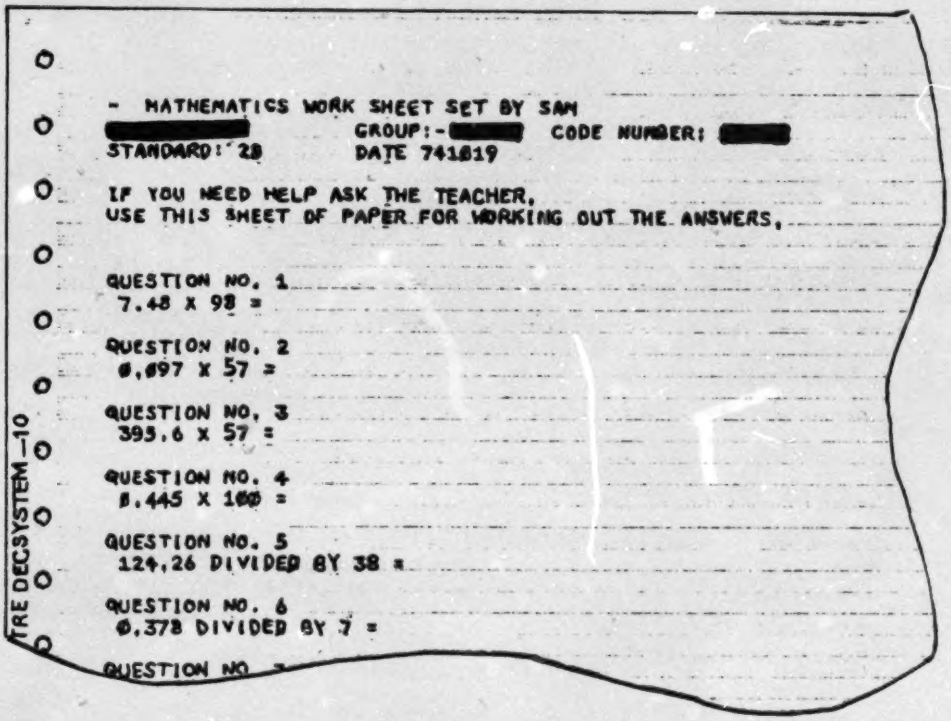
The teacher may intervene from time to time and restandardise either part (or the whole) of the class to correspond with the associated work being done at the time. Otherwise in any teaching group pupils would be spread throughout the whole of standards in the course.

PROGRESS REPORTS

As with ESYMRK, SAM provides the teacher with the facilities to obtain a number of reports, one detailing current progress and the other accumulative past history. In the case of SAM, these details are related more to the standards and the route taken through a standard block than the marks, as they are more significant.

EVALUATION DATA

Similarly, evaluation procedures presenting the author with objective data are provided by the SAM system. Again these relate more to the routes taken by pupils through standard blocks than actual marks obtained. However, the data is detailed enough to allow authors to consider the suitability of standard(s) or even questions.



- MATHEMATICS WORK SHEET SET BY SAM

[redacted] GROUP:-[redacted] CODE NUMBER: [redacted]

STANDARD: 28 DATE 741819

IF YOU NEED HELP ASK THE TEACHER.
USE THIS SHEET OF PAPER FOR WORKING OUT THE ANSWERS.

QUESTION NO. 1
7.48 X 98 =

QUESTION NO. 2
0.097 X 57 =

QUESTION NO. 3
395.6 X 57 =

QUESTION NO. 4
8.445 X 100 =

QUESTION NO. 5
124.26 DIVIDED BY 38 =

QUESTION NO. 6
0.378 DIVIDED BY 7 =

QUESTION NO

TRE DECSYSTEM-10

EVALUATION

The project has two major aims in evaluation:-

(1) to collect feedback for continuous assessment and improvement of the course

(2) to provide descriptive data for interested audiences.

The main source of feedback is via the individual teacher. Participating teachers are invited to comment at each stage in the development of the educational material particularly after trial in the classroom. The project relies heavily on the teachers for this information, and school representatives meet regularly with the project team for discussion of educational issues.

Alongside teachers reports, project staff visit schools on a regular basis to evaluate the course material in the classroom, and the effect of the system on classroom mechanics.

A report is produced at the end of each module incorporating project observation, teachers' comments and proposals for future improvements. Comments are always welcomed from independent observers.

The computer system has been designed to produce feedback on the educational material for authors.

An author can obtain registers for any class for any module, and hence can monitor pupil progress and attainment for a given module.

A module response report is produced daily. This records, for each anticipated response to a question the number of pupils giving that response and up to 32 unanticipated responses. From this authors can amend and update answer files to give appropriate comments to pupil responses. Authors can also request a module contingency report giving pupils' scores on each question in the module. This gives information on discriminatory potential and interdependence of questions.

During development the project has also produced a number of papers and reports on various aspects of the course. Teachers are also asked to complete questionnaires assessing the value and effect of teacher support, in-service training, etc.

Apart from in-house evaluation, the project is under constant observation by a team of professional evaluators from the University of East Anglia. They too, visit schools and produce papers and reports for interested audiences.

Of all the audiences that the Project faces one of the most unsung and rarely highlighted is that of pupils.

> *" I would like you to know how much I am enjoying this new Maths Project. Because at my junior school I didn't like Maths at all I used to think it was the most boring subject but now I have started this new kind of maths I am really enjoying it. "*

COMPUTER SYSTEM OPERATION

The Project was initially thought of as an on-line interactive package with pupils coding their SAM and ESYMRK answers onto OMR cards and 'posting' them into a card reader. Their assessment would be immediate and formatted onto teletype paper that should be retained by the pupil. For a number of reasons (not entirely cost) the project has rejected this approach for two others:

i) Batch entry from a central point

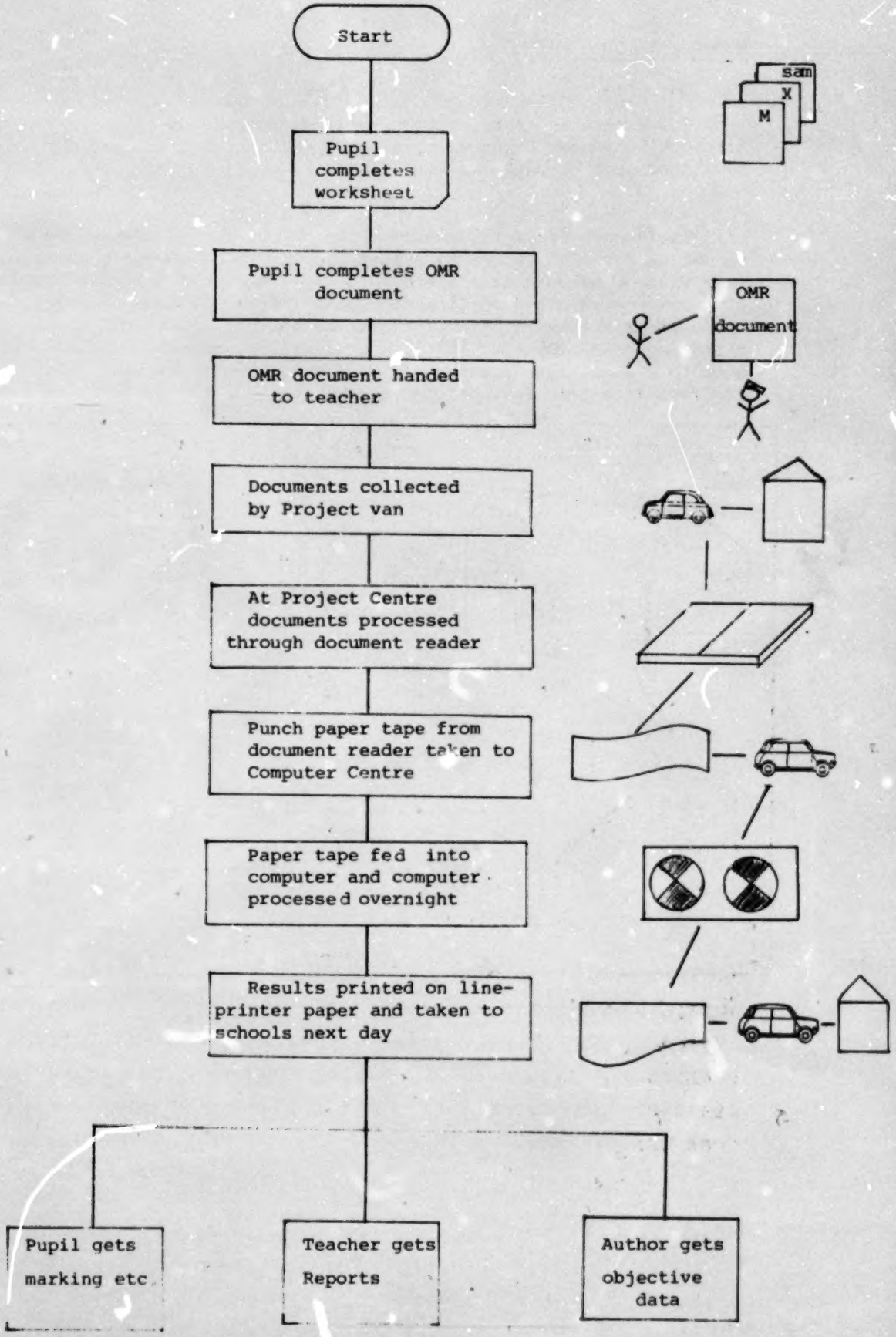
ii) Remote Job Entry for Batch

CENTRAL BATCH

The Project has adopted the central batch system in Hertfordshire shown opposite.

Pupils code their SAM or ESYMRK answers onto OMR documents which are collected from the school each day by a project courier. The work is processed overnight at the County Hall Computer Centre (ESYMRK) and at Hatfield Polytechnic Computer Centre (SAM).

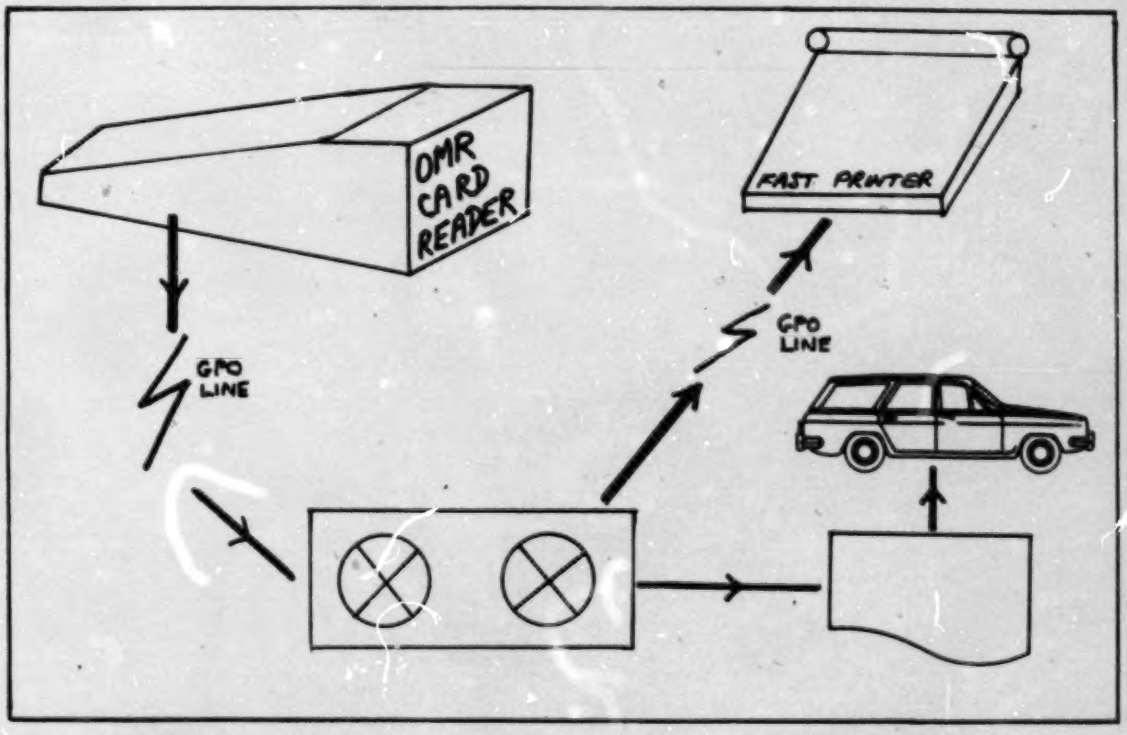
The Project courier delivers the assessment early next morning in time for the first mathematics lesson of the day. Hence during normal operations no pupil has to wait more than 12 hours for the results of his or her work. This service is maintained five days a week.


Start
Pupil completes worksheet
Pupil completes OMR document
OMR document handed to teacher
Documents collected by Project van
At Project Centre documents processed through document reader
Punch paper tape from document reader taken to Computer Centre
Paper tape fed into computer and computer processed overnight
Results printed on line-printer paper and taken to schools next day
Pupil gets marking etc
Teacher gets Reports
Author gets objective data
sam
X
M
OMR document

REMOTE JOB ENTRY

The Remote Job Entry system evolved from the on-line system. Although no longer being used in Hertfordshire, the Project has developed such a system in the I.L.E.A.

The Remote Job Entry system shown below, relies on the use of an OMR card reader linked by a fast GPO line to a computer system. Work will be batched at the end of a day (submitted on cards instead of documents) and fed on-line to a data file. The data is processed by conventional means at a time that is appropriate to the local operating conditions for that computer centre, and the output either sent to a local line printer and delivered by a courier, or sent down the fast line to a fast printer at the remote entry point



BOTH CENTRAL BATCH AND REMOTE JOB ENTRY BATCH REQUIRE LOCAL INPUT AND OUTPUT ROUTINES. THE MAIN PROCESSING HOWEVER IS DONE BY A STANDARD SUITE OF BATCH PROGRAMS THAT CAN EASILY BE ADAPTED TO THE HARDWARE CONFIGURATION OF THE USER'S COMPUTER SYSTEM.

HOW MUCH DOES IT COST ?

Anyone taking over a new teaching scheme is bound to ask what does it cost? The terms of reference under which the NDP grant was given specified that computer managed learning should be undertaken at 'reasonable cost'. Although the development grant was generous, the ongoing costs have always been looked at with great scrutiny. It is for this reason that children receive only 1/4 sheet of lineprinter output.

No one seems quite sure how reasonable 'reasonable cost' should be, but it is fairly clear that for a school-based project 'reasonable' can only mean dirt cheap and in the present economic climate it must be cheaper than this.

It is not appropriate to give precise figures for costs in Hertfordshire. Not because these figures are not available (this project has probably been more carefully costed than most similar curriculum innovations), but because inflation and local peculiarities render these largely irrelevant to other authorities considering implementation.

Aside from staffing there are five broad headings under which costs may be reckoned. Some of these directly affect the schools, others apply to the central organisation. Some are dependent on the number of children, others on the number of schools, yet others on the geographical location of the schools.

First, classroom materials (worksheets, games, studysheets, teachers notes, etc.). The cost of these depends in part on the cost of raw material and also on the cost of reprographic facilities. In Hertfordshire, the worksheets are disposable, but paper costs have risen sharply since the project began, and an obvious long-term economy would be re-usable sheets.

Secondly, television programmes. The cost of these includes the cost of video-tapes and also the costs of copying from master programmes. The overall cost of television in the project could not be defended except that in Hertfordshire there is already a strong commitment to television, and studio and copying facilities and replay equipment in schools are already provided and well-used in other subject areas.

The use of a computer to mark work produces costs in two further areas: data capture and computer processing. These costs are both highly-dependent on local circumstances: Hertfordshire uses commercially-printed mark-sensed documents and a document reader, whereas ILEA uses mark-sensed cards and a card reader. Computer costs also vary from computer to computer.

Further, most computer-managed schemes require some data-transfer service. In Hertfordshire, there is a van collection and delivery service. Again the models adopted and hence costs are very dependent on the environment and can usually be absorbed by existing resources.

Of course all costs must be measured against the effectiveness of the scheme; HCMMP will not turn a bad teacher into a good one although we hope it will turn an average teacher into a better one.

SUMMARY

The Project has moved slowly towards a situation where development is giving way to production both for local and external use. The overriding feelings of most of the users has been that, given a reliable operating system, the computer has many obvious benefits as a management tool in education and in particular in dealing with all ability mathematics classes. To quote a potential customer, "I want the computer managed system to help overcome the problems my department is facing with the marking and subsequent control of my department's all ability classes". This is what HCMMP has aimed to achieve and has found not a little success.

What of the future however? Already "old hands" within Hertfordshire are seeing improvements that they want built into the system, especially in terms of added flexibility of routing and decentralisation of control and subsequent development. HCMMP is a first step into the relatively new and untried field encompassing the marriage of education and its use of computer technology and as such could be considered a foundation for future developments. The form of these developments will not be limited to the existing structure and approach but will branch out to more sophisticated techniques and varied directions.

APPENDIX 1. ESYMRK SYLLABUS (IN BRIEF)

YEAR 1.		YEAR 2.	
Module		Module	
0	Introduction to the Course	20	Algebra 1.
1	Set Theory 1.	21	Solids
2	Number	22	Directed Numbers
3	Fractions 1.	23	Graphs
4	Decimals 1.	24	Algebra 2.
5	Angles	25	Percentages
6	Coordinates	26	Reflection
7	Symmetry	27	Set Theory 2.
8	Area	28	Equations (Algebra 3)
9	Fractions 2.	29	Plane Regions
10	Statistics	30	Ratio and Enlargement
11	Decimals 2.	31	Rotation
		32	Translation

TECHNICAL DETAILS (IN BRIEF)

SYSTEM NAME : ESYMRK

PROGRAM LANGUAGE : COBOL

VERSIONS : NCR CENTURY
(at present) DECsystem 10

PROGRAM SIZE : Maximum core 64k Bytes

FILE DETAILS : Register M/F up to 1.6k Bytes / Pupil
Response M/F up to 90k Bytes / Module
Transaction File up to 1k Bytes / Pupil.

Opposite is the ESYMRK program flowchart, and for further details refer to the Project Publications :-

i) ESYMRK SYSTEMS SPECIFICIATION

ii) ESYMRK PROGRAM SPECIFICATIONS

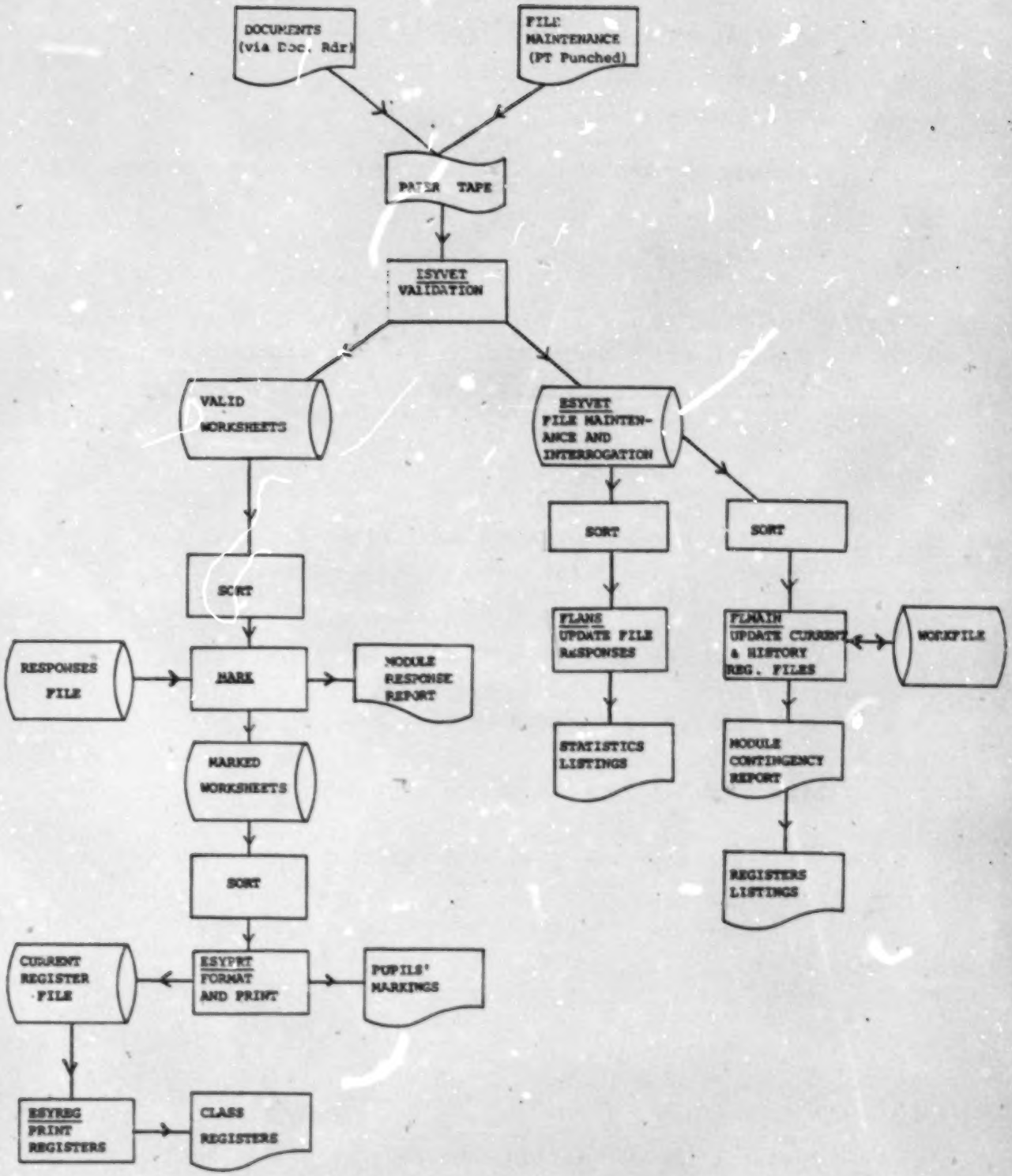
iii) ESYMRK PROGRAM DOCUMENTATION

iv) FLMAIN - Users Guide to Updating the Register Files.

v) FLANS - Users Guide to Updating Module Response File.

vi) ESYMRK REGISTER - Details of Registers Available to Teachers.

ALL ON DEMAND ONLY, AT COST.


DOCUMENTS (via Doc. Rdr)
FILE MAINTENANCE (PT Punched)
PAPER TAPE
ISYVET VALIDATION
VALID WORKSHEETS
ESYVET FILE MAINTENANCE AND INTERROGATION
SORT
SORT
SORT
RESPONSES FILE
MARK
MODULE RESPONSE REPORT
FLANS UPDATE FILE RESPONSES
FLMAIN UPDATE CURRENT & HISTORY REG. FILES
WORKFILE
STATISTICS LISTINGS
MODULE CONTINGENCY REPORT
MARKED WORKSHEETS
SORT
REGISTERS LISTINGS
CURRENT REGISTER FILE
ESYPRT FORMAT AND PRINT
PUPILS' MARKINGS
ESYREG PRINT REGISTERS
CLASS REGISTERS

TECHNICAL DETAILS (IN BRIEF)

SYSTEMS NAME :	SAM/SAL *
PROGRAMMING LANGUAGE :	A combination of FORTRAN, COBOL and BCPL
VERSIONS : (at present)	DECsystem 1Ø

The transfer version described here will not be available until Easter 1977, at present a non-documented BASIC version is being used.

Opposite is the SAM/SAL program flowchart, but for further details refer to the Project Publications :-

i) SAM/SAL Systems Specification

ii) SAM/SAL Program Specifications +

iii) SAM/SAL Program Documentation +

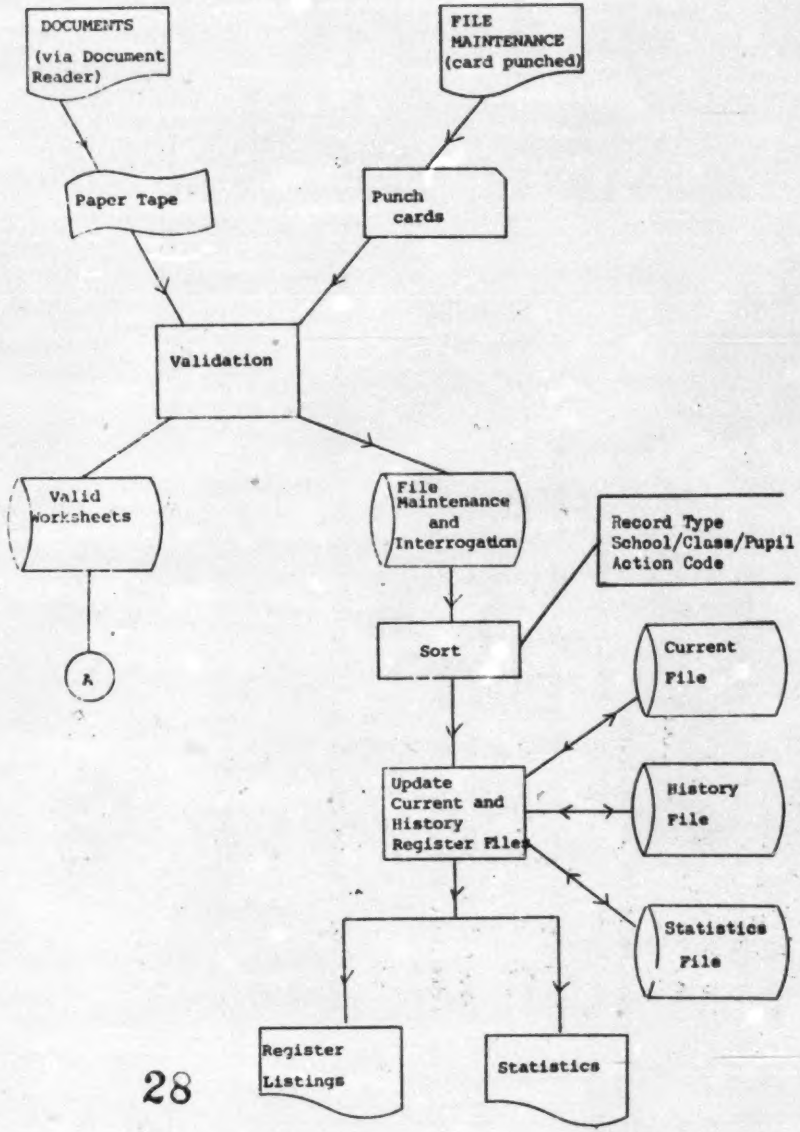
iv) S.A.L. - Users Guide to writing a standard +

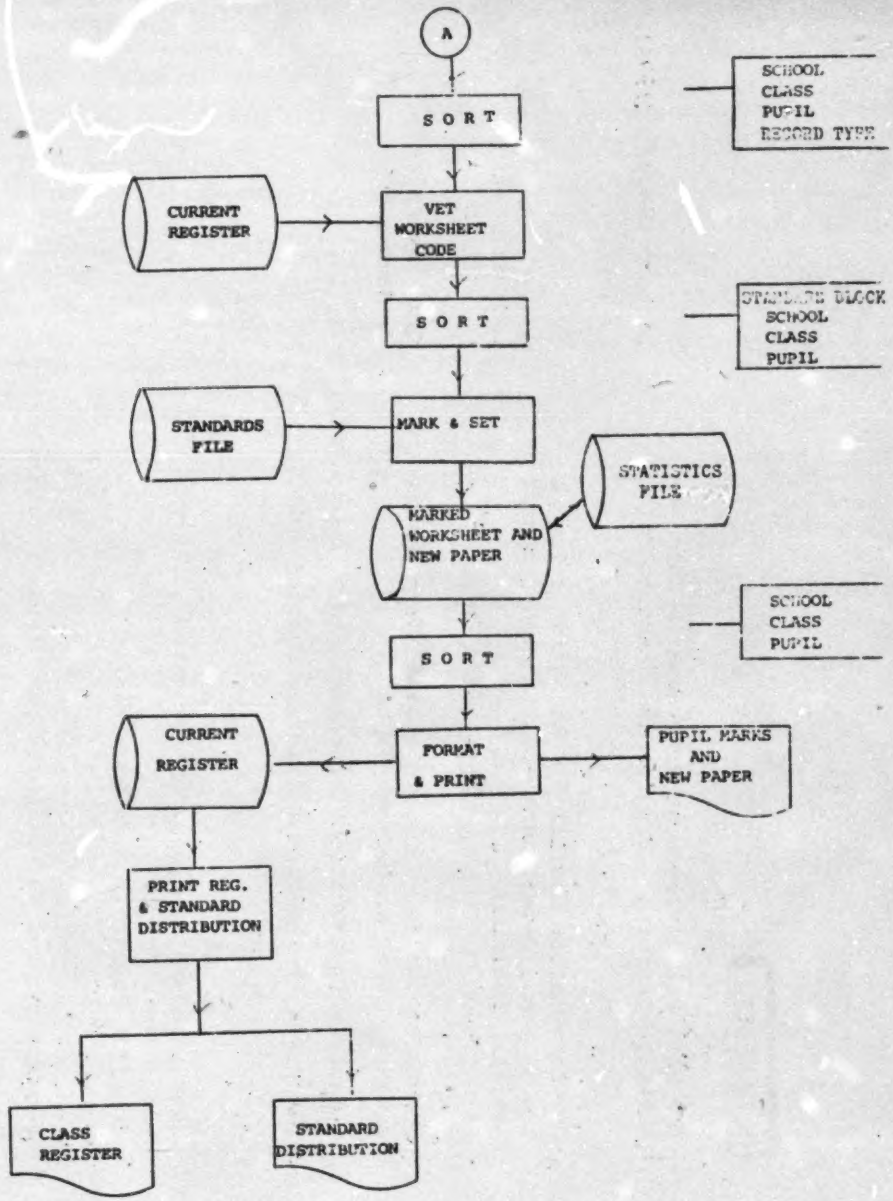
v) SAMEDT - Users Guide to Updating the Registers File+

vi) SAM REGISTERS - Details of Registers available to teachers. +

* *SAL is the SAM AUTHOR LANGUAGE used by authors to define the 'picture' of the standards for generation of the worksheets.*

+ *Available from Easter 1977.*


DOCUMENTS
(via Document Reader)
FILE MAINTENANCE (card punched)
Paper Tape
Punch cards
Validation
Valid Worksheets
A
File Maintenance and Interrogation
Record Type
School/Class/Pupil
Action Code
Sort
Current File
Update Current and History Register Files
History File
Statistics File
Register Listings
Statistics


A
SORT
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VET WORKSHEET CODE
SORT
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CLASS
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STANDARDS FILE
MARK & SET
STATISTICS FILE
MARKED WORKSHEET AND NEW PAPER
SCHOOL
CLASS
PUPIL
SORT
CURRENT REGISTER
FORMAT & PRINT
PUPIL MARKS AND NEW PAPER
PRINT REG. & STANDARD DISTRIBUTION
CLASS REGISTER
STANDARD DISTRIBUTION

REFERENCES

The National Development Programme in Computer Assisted Learning - Origins and Starting Point. Richard Hooper (1974)

CET Information Leaflet 9 - An Introduction to the National Development Programme in Computer Assisted Learning. CET Publications

The Hertfordshire Computer Managed Mathematics Project - IFIP Conference Paper C.M. Leeson and J. Jaworski.

Computers in Education, O.Lecarme and R.Lewis (Eds).

(© IFIP North Holland Publishing Company 1975.)

What is HCMMP ? - A parent-oriented questions and answers guide.
(Project Publication 7606-JJ-WIH)

A number of teacher-oriented pamphlets, including

Project Structure
(Project Publication 7606-CML-PSO)

Details of the administrative and operational side of the project in Hertfordshire.

The ESYMRK Syllabus
(Project Publication 7606-HCMMP-SYLL)

See Appendix 1.

Document Data Capture
(Project Publication 7606-CLE-DOC)

Details on how to code an OMR document.

Use of the VTR & MONITOR
(Project Publication 7606-JJ-VTR)

(All of these are liable to change or replacement at any time)

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Herts.

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